SINGLE PASS COLLIDER MEMO CN- 290 MASTER

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TITLE: BEAM TESTS OF PHOSPHORESCENT SCREENS *

Twelve phosphorescent screens were beam tested for linearity, uniformity, low radiation damag and a suitable emitted wavelength for use with television cameras. One screen was chosen for the construction of several intercepting profile monitors which were used during the SLC Ten Sector Tests[1] to measure the emittance and wakefield effects of a damped ele tron beam.

The screens that were tested are listed in Table 1. Their manufacturers and other pertinent properties are also shown. Most of the screens were produced by settling powdered phosphor onto aluminum. The settling procedure suggested by GTE/SYLVANIA Corporation[2] is included as Appendix A, and this procedure adapted for use at SLAC appears as Appendix B.

The brightness and linearity te ts were conducted in End Station A using the equipment shown in Fig. . The linearity of the Ultricon[3] camera was tested with a constant light source and neutral density filter and was found to be good to a few percent over the range used here. The spectral response of the Ultricon camera is shown in Fig.2. The End Station electron beam was focused to a two millimeter diameter spot and had a 100 nsec duration. The line received beam at ten hertz. The output data was a digitized video signal (vertical) processed by a Colorado Video Unit[4] and viewed on an oscilloscope. Several frames following the beam passage were measured to determine the decay time. The test results are shown in Fig. 3. All phosphorescent screens appeared linear within the accuracy of the experiment. [A note of caution: the measurements of the particle flux below 5×10^{8} electrons per pulse have larger errors than the rest of the range.]

Partial life tests of screens #8 and #11 were performed in air at the end of the achromatic spectrometer in Sector 10. In the first test, 5×10^{15} electrons were passed through each screen in a 500 micron diameter circle in 15 minutes. As a result, screen #8 had severe radiation damage, and screen #11 had slight but measurable damage. In both cases the damaged phosphor had been removed by the beam from the screen at the location of impact. It is not known if damage to the binder was at fault.

In another test, 1.6×10^{15} electrons in the same size circle on screen #11 produced no damage, but 5×10^{14} electrons damaged screen #8.

The phosphor screen #11 ($Gd_2 O_2 S:Tb$)[2] was chosen for use in the high resolution profile monitors built for the Ten Sector Tests. The reasons for selection are that this phosphor settled well, produced a very uniform surface, its green emission matched the response of the Ultricon camera, and it was reasonably radiation hard. The aluminum substrate used for the target is shown in Fig. 4. The holes are for in situ distance calibrations. The phosphor was settled using the procedure in Appendix B. The deposited phosphor-binder layer was approximately 0.0035 inches thick.

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One of these profile monitors was used to observe the size of an electron beam extracted from the South Damping Ring. With optics conditions listed in Fig. 1, gaussian beam heights (sigma) slightly less than 80 microns have been measured. This size is not inconsistent with the expected resolution given by the optical system and natural beam size. Therefore, the screen resolution is certainly better than 80 microns.

Many thanks to R. Stiening for suggesting this study, K. Jobe for helpful suggestions, J. Pope and D. Walz for kindly providing a sample of their very robust SLAC chromated screen and N. Palmer and R. Tankersley for the mechanical design of the profile monitor. Modest quantities of all phosphors are available for use by interested parties.

REFERENCES:

1. J. Sheppard et al., SLAC-PUB-3284, January 1984, submitted to 1984 Linac Conference.

2. GTE/SYLVANIA Products Corporation, Hawes Street, Towanda, Pennsylvania 18848.

3. RCA, 4546 El Camino Real, Los Altos, CA 94022.

4. Colorado Video Inc., Box 928, Boulder, Colorado 80306.

5. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Division, Wilmington, DE 19898.

J. Pope and D. Walz of SLAC have improved the screen of Ref. 7.

7. R. Allison et al., "A Radiation-Resistant Chromium-Activated Aluminum Oxide Scintillator," UCRL-19270, UC-37 Instruments, TID-4500 (54th Ed.), University of California, Berkeley, CA (1969).

TABLE I. PHOSPHORESCENT SCREEN INFORMATION

Screen #	Name	Manufacturer	Color**	Substrate	Comments
1	Cronex CB-2	Du Pont[5]	Yellow	Plastic	Not good for vacuum, bright.
2	Cronex Quanta V	Du Pont	Green	Plastic	Not good for vacuum.
3	Cronex Lighting Plus	Du Pont	Blue	Plastic	Not good for vacuum.
4	SLAC Chromate Screen	SLAC[6,7]	Red	Aluminum	Radiation resistant, grainy, robust.
5	$ZnS:Ag$	Sylvania[2]	Blue	Aluminum*	Radiation soft.
6	$Gd_2O_2S:Tb$	Sylvania	Green	Aluminum*	Made very thin for test.
7	$ZnS:Mn:Cu$	Sylvania	Yellow	Aluminum*	Radiation soft.
8	$ZnS:Cu$	Sylvania	Green	Aluminum*	Radiation soft.
9	$(Zn,Mg)_3(PO_4)_2:Mn$	Sylvania	Red	Aluminum*	Long persistence
10	$Zn_2SO_4:Mn$	Sylvania	Green	Aluminum*	Long persistence
11	$Gd_2O_2S:Tb$	Sylvania	Green	Aluminum*	Good
12	$Ba_3(PO_4)_2:Eu$	Sylvania	Blue	Aluminum*	Dim

* Settled

** Emitted color

The measured decay times of the phoshor and camera systems are 17 msec for screens 2,3,6,7,8,11,and 12, 34 msec for screens 1 and 4, 50 msec for screen 5, and 100 msec for screens 9 and 10.

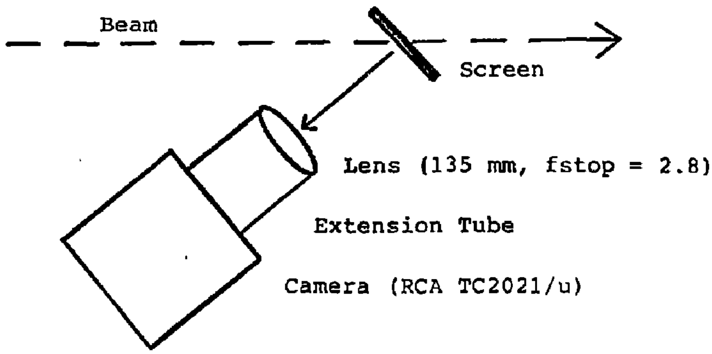

Fig. 1 Screen test configuration. Extension tube length and magnification for the End Station A tests are 6 cm and 0.48 and for the high resolution profile monitor 13 cm and 1.00, respectively.

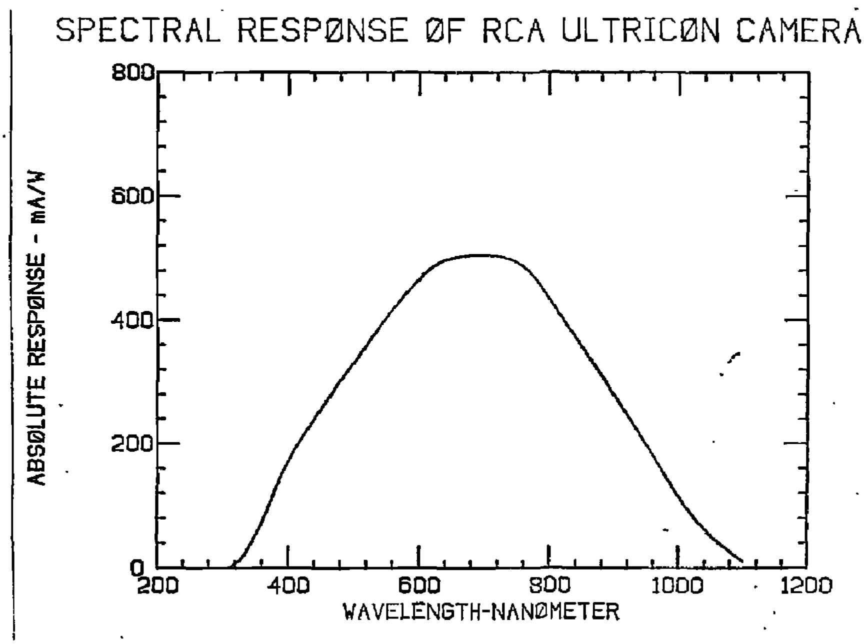

Fig. 2 Spectral response of test camera (from RCA AN-6994, C. Newcomer, 1981).

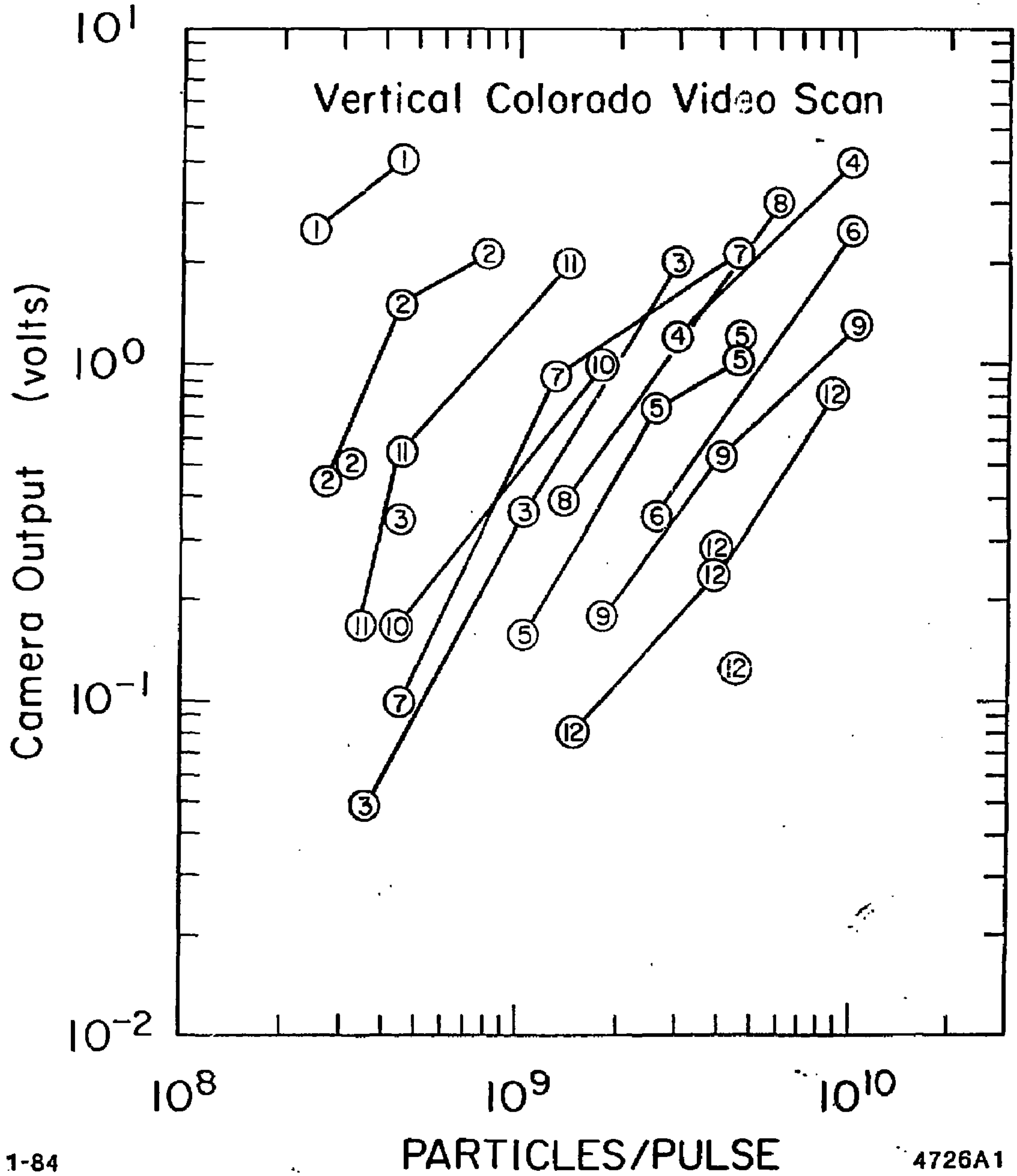

Fig. 3 Camera output voltage versus beam intensity for twelve test phosphorescent screens.

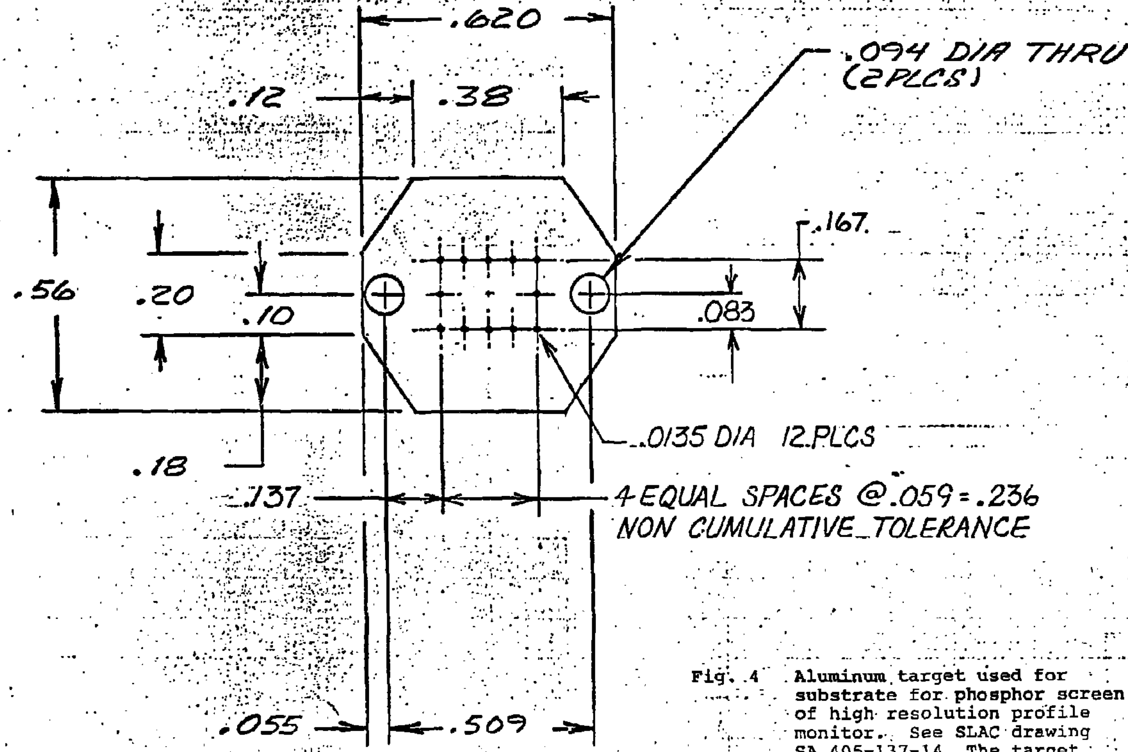

Fig. 4 Aluminum target used for substrate for phosphor screen of high resolution profile monitor. See SLAC drawing SA 405-137-14. The target is 0.016 inches thick.

SYLVANIA Chemicals/Metals GTE
Phosphors and Chemicals
Technical Information Bulletin

METHOD OF SETTLING PHOSPHOR SLIDES

This method of settling phosphor slides is suitable for preparing samples for brightness, color, persistence, and visual evaluation under various types of excitation. The quantities of materials used can be scaled up or down linearly with the bottom area of the settling chamber.

EQUIPMENT

Settling chamber - 6" x 6" x 10" high - bottom drain optional.

Funnel with dispersing tip - hole should spray horizontally.

Funnel support.

250 Ehrlenmeyer flask.

Balance - sensitive to 0.01 g.

Glass slides.

MATERIALS

Phosphor.
1% barium acetate solution.
Potassium silicate - PS-6.
Deionized water.

PROCEDURE

1. For good draining of slides, slant chamber 3-5° from horizontal.
2. Put three liters of water in chamber.
3. Place slides in chamber away from edges - position slides with stirring rod.
4. Add 34 ml of 1% barium acetate solution.
5. Place funnel and support on chamber.
6. Weigh desired amount of phosphor (0.93 g will yield 4.0 mg/cm^2).
7. Disperse phosphor in 100 ml water and 34 ml PS-6 in flask.
8. Shake suspension and pour into dispersing funnel.
9. Rinse flask with 25 ml water and pour into funnel.
10. Allow to settle 20 minutes.
11. Slowly decant supernatant liquid by draining or siphoning, being careful not to disturb slide.
12. Carefully remove slides and dry in air.
13. The slides can now be excited and evaluated.

This procedure is meant only as a guide and may be modified to suit individual needs and equipment.

APPENDIX B

Settling Procedure for High Resolution Screens

I. Clear area. Set up digital scale.

II. Clean and dry carefully the following equipment:

- 1 Erlenmeyer flask (glass, 250 ml)
- 1 Beaker (glass, 400 ml, straight sides, flat bottom)
- 2 Eye droppers (glass) [for solution transfers]
- 1 Glass funnel (small)
- 1 Glass microscope slide [for phosphor transfer]

III. Clean aluminum targets with alcohol then distilled water thoroughly.

IV. Place into Erlenmeyer flask 50$\pm$10 grams of distilled deionized water, 4.00 $\pm$ 0.05 grams of potassium silicate solution[2] and 0.40 $\pm$ 0.04 grams of phosphor ($Gd_2O_2S{:}Tb$).*

V. Place into glass beaker aluminum targets, 70$\pm$10 grams of distilled water, and 4.00 $\pm$ 0.05 grams of 1% barium acetate solution.

VI. Shake Erlenmeyer flask to suspend phosphor in the water. Pour contents carefully into the beaker using the glass funnel so as not to disturb the aluminum targets. Allow the phosphor and binder (barium silicate) to settle for 30 minutes.

VII. Remove targets from water. This step ruins approximately one half the screens, so great care is suggested.

VIII. Air dry the screens for several days in a protected place. Experience has shown that no vacuum baking is needed before using these screens in an ultra high vacuum system. However, a moderate temperature bake will not harm the screens and is recommended.

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*Weight of phosphor is empirically determined to provide an acceptable layer.